

CLAIMS

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is as follows:

- 1 1. A method of protecting a flowable oxide in a
- 2 semiconductor device, said method including the
- 3 steps of
- 4 depositing a flowable oxide insulator layer on
- 5 a substrate, said substrate having a substrate
- 6 surface and a stud, said stud being electrically
- 7 conductive, said flowable oxide insulator layer
- 8 having a upper FOX insulator layer surface,
- 9 etching said flowable oxide insulator layer to
- 10 form a trough substantially defined by sidewalls of
- 11 said flowable oxide insulator layer and by said
- 12 substrate surface, said trough exposing said stud,
- 13 forming a primary protective layer on said
- 14 sidewalls of said flowable oxide insulator layer,
- 15 said primary protective layer preventing the
- 16 exposure of the flowable oxide insulator layer to
- 17 moisture and lithographic resist developers, said
- 18 primary protective layer being impervious to copper
- 19 extrusion, and
- 20 forming a secondary protective layer in said
- 21 trough upon said primary protective layer and upon
- 22 said substrate surface, said secondary protective
- 23 layer being in electrical communication with said
- 24 stud.

1 2. The method of protecting a flowable oxide as
2 claimed in claim 1, wherein the step of etching the
3 flowable oxide insulator layer to form a trough
4 forms a plurality of troughs, each one of said
5 plurality of troughs defined by said sidewalls of
6 said flowable oxide insulator layer and by said
7 substrate surface.

1 3. The method of protecting a flowable oxide as
2 claimed in claim 1, wherein said primary protective
3 layer is discontinuous within said trough and said
4 secondary protective layer is continuous within said
5 trough.

1 4. The method of protecting a flowable oxide as
2 claimed in claim 1, further comprising the step of
3 oxidizing said upper FOX insulator layer surface,
4 thereby forming a oxidized FOX layer.

1 5. The method of protecting a flowable oxide as
2 claimed in claim 4, wherein said upper FOX insulator
3 layer surface is oxidized in an O₂ plasma.

1 6. The method of protecting a flowable oxide as
2 claimed in claim 4, wherein said oxidized FOX layer
3 is less than 500 Angstroms thick.

1 7. The method of protecting a flowable oxide as
2 claimed in claim 4, further comprising the step of
3 forming a oxide layer on said oxidized FOX layer.

1 8. The method of protecting a flowable oxide as
2 claimed in claim 7, wherein said oxide layer is
3 formed by low plasma chemical vapor deposition.

1 9. The method of protecting a flowable oxide as
2 claimed in claim 7, wherein said trough is formed
3 after said oxidized FOX layer is formed and after
4 said oxide layer is formed.

1 10. The method of protecting a flowable oxide as
2 claimed in claim 9, wherein said primary protective
3 layer is formed by oxidizing said sidewalls of said
4 flowable oxide insulator layer.

1 11. The method of protecting a flowable oxide as
2 claimed in claim 9, wherein said trough is formed by
3 a reactive ion etch with fluorocarbon gases and said
4 primary protective layer is formed during said
5 reactive ion etch.

1 12. The method of protecting a flowable oxide as
2 claimed in claim 9, wherein said primary protective
3 layer is formed by the same process used to form
4 said oxidized FOX layer.

1 13. The method of protecting a flowable oxide as
2 claimed in claim 9, wherein said primary protective
3 layer is less than 500 Angstroms thick.

1 14. The method of protecting a flowable oxide as
2 claimed in claim 9, further comprising the steps of
3 depositing a conductor in said trough and smoothing

4 said conductor and said oxide layer thus forming an
5 even planar surface by said conductor and said oxide
6 layer, said conductor being in electrical
7 communication with said secondary protective layer.

1 15. The method of protecting a flowable oxide as
2 claimed in claim 14, wherein said conductor is
3 copper.

1 16. The method of protecting a flowable oxide as
2 claimed in claim 14, wherein said step of smoothing
3 said conductor and said oxide layer is performed by
4 polishing.

1 17. The method of protecting a flowable oxide as
2 claimed in claim 14, further comprising the steps of
3 depositing a nitride layer on said even planar
4 surface,
5 depositing another flowable oxide insulator
6 layer on said nitride layer, said another flowable
7 oxide insulator layer having another upper FOX
8 insulator layer surface,
9 oxidizing said another upper FOX insulator
10 layer surface, thereby forming another oxidized FOX
11 layer,
12 forming another oxide layer on said another
13 oxidized FOX layer,
14 etching said another oxide layer, said another
15 oxidized FOX layer, said another flowable oxide
16 insulator layer, and said nitride layer to form
17 another trough substantially defined by another

18 sidewalls of said another flowable oxide insulator
19 layer and by said even planar surface,
20 forming another primary protective layer on
21 said another sidewalls of said another flowable
22 oxide insulator layer, said another primary
23 protective layer preventing the exposure of said
24 another flowable oxide insulator layer to moisture
25 and lithographic resist developers, said another
26 primary protective layer being impervious to copper
27 extrusion,
28 forming another secondary protective layer in
29 said another trough upon said another primary
30 protective layer and upon said even planar surface,
31 said another secondary protective layer being in
32 electrical communication with said conductor,
33 depositing another conductor in said another
34 trough, said another conductor being in electrical
35 communication with said another secondary protective
36 layer, and
37 smoothing said another conductor and said
38 another oxide layer thus forming another even planar
39 surface by said another conductor and said another
40 oxide layer.

1 18. The method of protecting a flowable oxide as
2 claimed in claim 17, wherein said another oxide
3 layer is thicker than said oxide layer.

1 19. The method of protecting a flowable oxide as
2 claimed in claim 17, wherein said another flowable
3 oxide insulator layer is thicker than said flowable
4 oxide insulator layer.

1 20. The method of protecting a flowable oxide as
2 claimed in claim 19, wherein said another trough has
3 multifaceted contours.

1 21. The method of protecting a flowable oxide as
2 claimed in claim 17, wherein said secondary
3 protective layer and said another secondary
4 protective layer are formed from Tantalum
5 Nitride/Tantalum.

1 22. A method of protecting a flowable oxide in a
2 semiconductor device, said method including the
3 steps of

4 depositing a flowable oxide insulator layer on
5 a substrate, said substrate having a substrate
6 surface and a stud, said stud being electrically
7 conductive, said flowable oxide insulator layer
8 having an upper FOX insulator layer surface,

9 etching the flowable oxide insulator layer to
10 form a trough defined by sidewalls of said flowable
11 oxide insulator layer and by said substrate surface,
12 said trough exposing said stud,

13 forming a primary protective layer on said
14 sidewalls of said flowable oxide insulator layer,
15 said primary protective layer preventing the
16 exposure of the flowable oxide insulator layer to
17 moisture and lithographic resist developers, said
18 primary protective layer being impervious to copper
19 extrusion,

20 forming a supplemental protective layer on said
21 primary protective layer, said supplemental

22 protective layer being impervious to moisture,
23 lithographic resist developers, and copper
24 extrusion, said supplemental protective layer
25 improving adhesion with a metallic conductor, and
26 forming a secondary protective layer in said
27 conductive trough upon said supplemental protective
28 layer and upon said substrate surface, said
29 secondary protective layer being in electrical
30 communication with said stud.

1 23. The method of protecting a flowable oxide as
2 claimed in claim 22, wherein said supplemental
3 protective layer is formed by nitridizing said
4 primary protective layer.

1 24. The method of protecting a flowable oxide as
2 claimed in claim 22, wherein said supplemental
3 protective layer is formed by treating said primary
4 protective layer with silicon carbide.

1 25. The method of protecting a flowable oxide as
2 claimed in claim 22, wherein said supplemental
3 protective layer is formed by treating said primary
4 protective layer with silicon nitride.

1 26. The method of protecting a flowable oxide as
2 claimed in claim 22, wherein said primary protective
3 layer and said supplemental protective layer are
4 discontinuous within said trough and said secondary
5 protective layer is continuous within said trough.

1 29. The integrated circuit semiconductor device as
2 claimed in claim 28, further comprising a second
3 damascene layer, said second damascene layer
4 comprising,
5 another flowable oxide insulator layer upon
6 said nitride layer,
7 another oxidized FOX layer upon said another
8 flowable oxide insulator layer,
9 another trough,
10 another sidewalls of said another flowable
11 oxide insulator layer,
12 another primary protective layer upon said
13 another sidewalls, said another primary protective
14 layer preventing the exposure of said another
15 flowable oxide insulator layer to moisture and
16 lithographic resist developers, said another primary
17 protective layer being impervious to copper
18 extrusion,
19 another secondary protective layer upon said
20 another primary protective layer and upon said even
21 planar surface, said another secondary protective
22 layer being in electrical communication with said
23 conductor, and
24 another conductor in said another trough, said
25 another conductor being in electrical communication
26 with said another secondary protective layer.

1 30. The integrated circuit semiconductor device as
2 claimed in claim 29, wherein said another trough is
3 a dual damascene trough.

31. The integrated circuit semiconductor device as claimed in claim 27, further comprising a supplemental protective layer on said primary protective layer, said supplemental protective layer being impervious to moisture, lithographic resist developers, and copper extrusion, said supplemental protective layer improving adhesion with a metallic conductor.

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